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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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Si aucun titre n'est indiqué se referer à la description.)

METHOD OF MANUFACTURING A COOLING PLATE AND A COOLING PLATE MANUFACTURED WITH THIS METHOD

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Method of manufacturing a cooling plate and a cooling plate manufactured with this method

The present invention concerns a method of manufacturing a cooling plate and a cooling plate manufactured with this method.

Background of the Invention

Cooling plates, also called "staves", have been used in blast furnaces for over a hundred years. They are arranged on the inside of the furnace shell and have internal coolant ducts, which are connected to the cooling water circuit of the furnace. Their surface facing the interior of the furnace can be lined with a refractory material. Connection pipe-ends for cooling water are arranged on the rear side of the cooling plate and lead out in a sealed manner through the furnace shell. Cooling passages of a plurality of cooling plates are connected in series and are connected to a cooling water circuit of the furnace by means of these connection pipe-ends which lead out of the furnace shell.

Until some years ago, most cooling plates in blast furnaces were cast iron cooling plates. There are different methods for manufacturing such cast iron cooling plates. According to a first method, a mould for casting a cooling plate body is provided with one or more sand cores for forming the internal coolant ducts. Liquid cast iron is then poured into the mould. This method has the disadvantage that the mould sand is difficult to remove from the cooling ducts and/or that the cooling duct in the cast iron is often not properly formed or not tight enough. In order to avoid the aforementioned disadvantages, it has been suggested to arrange preformed steel pipes in the mould and to pour the liquid cast iron around the steel pipes. However, these cast iron cooling plates with steel pipes have not proved satisfactory. Indeed, due to carbon diffusion from the cast iron into the steel pipes, the latter become brittle and may crack.

As an alternative to cast iron cooling plates, copper and recently steel

cooling plates have been developed. Different production methods have been proposed for copper "staves".

Initially an attempt was made to produce copper cooling plates by casting in moulds, the internal coolant ducts being formed by a sand core in the casting mould. However, this method has not proved to be effective in practice, because the cast copper plate bodies often have cavities and porosities, which have an extremely negative effect on the life of the plate bodies. The mould sand is difficult to remove from the cooling ducts and the cooling duct in the copper is very often not properly formed.

GB-A-1571789 suggests to replace the sand core by a pre-shaped metal pipe coil made from copper or high-grade steel when casting the cooling plates in moulds. The coil, which forms a spiral coolant duct, is arranged in the casting mould and the liquid cooper is poured around the coil. This method has also not proved effective in practice, because neither cavities and porosities in the copper plate body, nor problems at the interface between the metal pipe and the copper solidifying in the mould can be effectively prevented.

A cooling plate made from a forged or rolled copper slab is known from DE-A-2907511. The coolant ducts are blind holes introduced by mechanical drilling in the rolled copper slab. The blind bores are sealed off by soldering or welding in plugs. Then, connecting bores to the blind bores are drilled from the rear side of the plate body. Thereafter, connection pipe-ends for the coolant feed or coolant return are inserted into these connecting bores and soldered or welded in place. It has recently also been proposed to produce steel cooling plates using the same process. With these cooling plates the above-mentioned disadvantages of casting are avoided. In particular, cavities and porosities in the plate body are virtually precluded.

WO-98/30345 teaches to cast a preform of the cooling plate with the help of a continuous casting mould, wherein rod-shaped inserts in the casting duct produce ducts running in the continuous casting direction, which form coolant ducts in the finished cooling plate. A plate body is separated from the continu-

ously-cast preform by making two cuts transversely with respect to the casting direction, forming two end faces, the distance between which corresponds to the desired length of the cooling plate. In the next production step, connection bores which open out into the through-passages, are drilled into the plate body perpendicular to the rear surface, and the end-side openings of the cast-in ducts are closed. Thereafter, connection pipe-ends are inserted into the connection bores and soldered or welded in place, as has already been described above.

The manufacturing methods described in DE-A 2907511 and in WO 98/30345 both enable high-quality cooling plate bodies to be produced from copper or copper alloys. However, compared to cooling plates with integrally cast cooling tubes or compared to shape-cast cooling plates, the finished cooling plates produced by both processes have the drawback of having a relatively high pressure loss in the region of the transitions from the connection pipe-ends to the cooling passages.

WO 00/36154 has suggested to reduce the flow losses in copper cooling plates with integrally cast or drilled cooling passages by inserting a shaped piece into a cutout in the cooling plate body, so as to form a diverting passage with optimized flow conditions for the cooling medium. However, this solution is relatively labor-intensive, which is reflected in higher production costs.

Summary of the Invention

It is an object of the present invention to provide a simple and reliable method of manufacturing cooling plates with relatively low pressure losses. It is another object of the present invention to provide a reliable cooling plate with relatively low pressure losses that can be easily manufactured. These problems are solved by a method in accordance with claim 1, respectively a cooling plate in accordance with claim 17.

A method of manufacturing a cooling plate in accordance with the present invention comprises following steps: providing a metallic plate body with a front

face, a rear face and at least one channel extending through the metallic plate body beneath its front face; inserting, with radial clearance, a metallic tube into the channel so that both tube ends protrude out of the channel, and achieving a press fit of the tube within the channel by shrinking the section of the channel and/or expanding the section of the tube.

When compared to copper or steel cooling plates having a forged or rolled plate body with drilled conduits for the cooling fluid, respectively to copper cooling plates with a continuously cast plate body in which the conduits for the cooling fluid are cast-in channels, the cooling plates of the present invention have e.g. following advantages:

- The tubes fitted in the plate body warrant leak tightness, even in case of corrosion, erosion, or cracking of the plate body. It follows that substantial economies may be made on the quality of the plate body.
- Due to the tube ends protruding out of the plate body, there is no necessity to weld connection pipe-ends into the plate body. It follows that a complicated welding operation, requiring highly qualified and experienced man power and involving a leakage risk due to welding defects, is definitely eliminated.
- The tubes with their ends protruding out of the plate body cause a much smaller pressure drop than connection pipe-ends that are welded from the rear face of the plate body into a drilled or cast channel. They also eliminate problems with "dead-ends", such as air pocket and solids accumulations, which are often at the origin of corrosion and flow restriction problems.

When compared to cast iron or copper cooling plates cast within a mould, wherein tubes forming the conduits in the finished cooling plates are arranged in the casting mould, the cooling plates of the present invention have e.g. following advantages:

- Because the plate body to be provided may be manufactured on the

basis of a rolled, forged or a continuously cast slab, it is relatively easy to reliably produce the required plate body at low costs, free of cavities and porosities and with a constant quality.

- Because the tubes are not cast into the plate body, it is not necessary to worry about interface problems between the tube material and a liquid plate body material solidifying around the tube.
- The press fit of the tube within its channel allows to warrant good and constant heat transfer properties between the tube and the plate.

Consequently, the present invention provides a simple and reliable method of manufacturing cooling plates with relatively low pressure losses, which have many advantages over prior art cooling plates.

A first method of achieving a press fit of the tube within the channel comprises following steps: dimensioning the channel section and the tube section so as to have radial interference when the plate body and the tube are at the same temperature; transforming the radial interference in a radial clearance by heating the plate body and/or cooling the tube; and, when sufficient radial clearance is achieved, inserting the metallic tube in the channel so that both ends protrude out of the channel. In this case, the press fit of the tube in the channel is then achieved when the temperature difference between the plate body and the metallic tube vanishes, i.e. when the plate body that is cooling down shrinks and/or the tube that is heating up expands.

A second method of achieving a press fit of the tube within the channel comprises rolling down the plate body after insertion of the metallic tube in the channel, so as to confer an oval section to the channel and the tube. This method has the additional advantage that the metallurgical structure of the plate body is further improved.

A third method of achieving a press fit of the tube within the channel comprises expanding the tube by establishing a hydraulic pressure inside the tube.

A fourth method of achieving a press fit of the tube within the channel

comprises expanding the tube with at least one explosion inside.

A fifth method of achieving a press fit of the tube within the channel comprises expanding the tube by pulling an expansion head there through.

It will be appreciated that it is also possible to successively execute two or more of the above methods to achieve the desired press fit of the tube in the channel.

The plate body is normally made of copper or steel. The tube fitted into the channel can e.g. be made of copper or stainless steel. The tube may be easily provided with a coating or lining further improving the heat transfer between the tube and the plate body and avoiding, if necessary, a direct contact between the metal of the plate body and the metal of the tube.

The tube ends protruding out of the channel are advantageously bent towards the rear of the plate body, so as to form a connection pipe-end pointing in a direction substantially perpendicular to a plane parallel to the rear face of the plate body. These connection pipe-ends may then directly pass through connection openings in the furnace shell, i.e. there is no welding or other pipe connection within the furnace. Furthermore, the bent tube ends are able to compensate, at least partially, temperature induced expansion/shrinking of the cooling plate in the furnace, so that no or simpler compensators will be required for connecting the connection pipe-ends to a cooling circuit.

The plate body is advantageously provided with a first perimeter face and an opposite second perimeter face, wherein the at least one channel extends through the metallic plate body so as to form a first opening in the first perimeter face and a second opening in the second perimeter face. This feature warrants a better cooling of the edges of plate body, where the tubes emerge out of the perimeter faces of the plate body. The perimeter faces are advantageously bevelled towards the rear face of the plate body, so that they form noses protecting the tube ends emerging out of the perimeter faces. To even better protect the tube ends emerging out of the perimeter faces, it is also possible to mill a recess into the perimeter face, so that the recess is open towards the rear

face of the plate body and one of the channel openings lies within this recess.

A cooling plate in accordance with the present invention comprises a metallic plate body with a front face, a rear face and at least one metallic tube extending through the metallic plate body beneath the front face so that both tube ends protrude out of the plate body. It is characterized by a press fit between the metallic plate body and the at least one metallic tube. The plate body is advantageously made of copper or steel. The tube is preferably made of copper or stainless steel. Each of the protruding tube ends is advantageously bent so as to form a connection pipe-end pointing in a direction substantially perpendicular to a plane parallel to the rear face of the plate body.

Brief Description of the Drawings

Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:

Fig. 1: is a longitudinal sectional view of a plate body for manufacturing a cooling plate in accordance with the invention;

Fig. 2: is a longitudinal sectional view of the plate body of Fig. 1, after having inserted, with radial clearance, a tube into a channel of the plate body;

Fig. 3: is a longitudinal sectional view of the plate body and tube of Fig. 2, after having achieved a press fit of the tube within the channel;

Fig. 4: is a longitudinal sectional view of the finished cooling plate;

Fig. 5: is an alternative embodiment of a cooling plate in accordance with the invention;

Fig. 6: is a longitudinal sectional view of a plate body with a tube inserted with radial clearance in a channel of the plate body, illustrating the step of expanding the tube with a hydraulic pressure inside to achieve a press fit of the tube within the channel;

Fig. 7: is a longitudinal sectional view of a plate body with a tube inserted with radial clearance in a channel of the plate body, illustrating the step of ex-

panding the tube by pulling a wedge-shaped head there through to achieve a press fit of the tube within the channel;

Description of a preferred embodiment

Fig. 1 shows a metallic plate body 10 to be used for manufacturing, in accordance with the present invention, a cooling plate (also called stave) to be arranged on the inside of the shell of a metallurgical furnace, e.g. a blast furnace. This plate body 10 has a front face 12, a rear face 14 and four perimeter faces. Two of these four perimeter faces are identified with reference numbers 16, 18, whereas the other two perimeter faces are not seen in the sectional view of Fig. 1. The two perimeter faces 16 and 18 are bevelled towards the rear face 14 of the plate body 10. The front face 12, which is exposed to the interior of the furnace, is advantageously provided with grooves 20, which increase the cooling surface and improve adherence of a refractory lining. Reference number 22 identifies a straight, cylindrical channel 22, which extends through the metallic plate body 10 beneath the front face 12 so as to form openings 24, 26 in the perimeter faces 16 and 18. The section of the channel is normally circular, but an oval section is not excluded. The plate body 10 includes several of such channels 22, which are normally all parallel to one another.

Such a plate body 10 is e.g. manufactured from a forged or rolled slab made either of copper, a copper alloy or steel, wherein channels 22 are drilled into the forged or rolled slab. Alternatively, the plate body 10 may also be manufactured from a continuously cast copper or steel slab, wherein the channels 22 are produced by rod-shaped inserts during the continuous casting operation, such as described e.g. in WO-98/30345. Thereafter, the cast-in channels can still be machined with a metal-cutting tool so as to improve their dimensional and form tolerances.

In accordance with the present invention, the channel 22 is not designed to form itself a conduit for the cooling fluid (normally cooling water), but to house

a metallic tube 30 that forms the conduit for the cooling fluid. As shown in Fig. 2, this metallic tube 30, which is preferably made of copper, a copper alloy or stainless steel, is inserted with radial clearance into the channel 22, so that both tube ends 32, 34 protrude from the channel 22. Thereafter, one achieves a press fit of the tube 30 within the channel 22, by shrinking the section of the channel 22 and/or expanding the section of the tube 30 within the channel 22 (i.e. by transforming the initial clearance fit into an interference fit). This press fit warrants a close contact between the external wall of the tube 30 and the internal wall of the channel 22, which results in a good heat exchange between the plate body 10 and the tube 30. Fig. 3 shows the plate body 10 with the tube 30 after having achieved a press fit of the tube 30 within the channel 22.

The desired press fit of the tube 30 in the channel 22 of the plate body 10 may be obtained according to different methods.

In accordance with a first method, the sections of the channel 22 and the tube 30 are dimensioned so as to warrant a radial interference when the plate body 10 and the tube 30 are both at the same temperature (i.e. the outer diameter of the tube 30 is slightly bigger than the inner diameter of the channel 22). Before inserting the tube 30 into the channel 22, this radial interference is then transformed in a radial clearance by heating the plate body 10 and, possibly, cooling the tube 30.

<u>Example 1:</u>

Tube diameter: 69,9-70,1 mm (at 20°C).

Channel diameter: 69,7-69,9 mm (at 20°C).

Desired clearance for inserting the tube into the channel: 0,2 mm on channel diameter.

This clearance is achieved by heating the plate body 10 to 420°C, if it is made of copper, or to 570°C, if it is made of steel.

When—after having inserted the tube 30 into the channel 22—the temperature difference between the plate body 10 and the tube 30 vanishes, the

radial clearance of the tube 30 in the channel 22 diminishes with the temperature difference, and a press fit of the tube in the channel is finally achieved.

In accordance with a second method, the sections of the channel 22 and the tube 30 are dimensioned so as to have radial clearance of the tube 30 in the channel 22 when the plate body 10 and the tube 30 are both at ambient temperature. After having introduced the tube 30 into the channel 22 of the plate body 10, the plate body 10 is rolled down. Thereafter, the originally cylindrical tube 30 has an oval section and a press fit of the tube 30 in the channel 22 is achieved.

Example 2:

Tube diameter: 69,9-70,1 mm (at 20°C)

Channel diameter: 70,3-70,8 mm (at 20°C)

Rolling down the plate by 1 mm will be sufficient to achieve a press fit of the tube 30 in the channel 22. The section of the tube 30 will become slightly oval.

In accordance with a third method, which is illustrated in Fig. 6, the sections of the channel 22 and the tube 30 are also dimensioned so as to have a radial clearance (i.e. positive allowance) of the tube 30 in the channel 22 when the plate body 10 and the tube 30 are both at ambient temperature. After having introduced the tube 30 into the channel 22 of the plate body 10, a conical expansion head 40 is pulled through the tube 30 by means of a hydraulic cylinder 42. This expansion head 40 expands the section of the tube 30 and thereby warrants a press fit of the tube 30 in the channel 22.

In accordance with a fourth method, which is illustrated in Fig. 7, the sections of the channel 22 and the tube 30 are again dimensioned so as to provide a radial clearance (i.e. positive allowance) of the tube 30 in the channel 22 when the plate body 10 and the tube 30 are both at ambient temperature. After having introduced the tube 30 into the channel 22 of the plate body 10, the tube 30 is expanded by means of a pressurized hydraulic fluid pumped into the tube

30. The device shown in Fig. 7 comprises a head 50 that is put in a sealed manner onto one end of the tube 30. This head 50 comprises a rod 52 that extends through the tube 30 to support a plug 54, which seals off the tube 30 near the opposite outlet of the channel 22. A channel 56 allows to pump the pressure fluid into tube 30. The hydrostatic expansion of the tube 30 warrants its press fit in the channel 22.

It will be appreciated that it is of course possible to successively execute two or more of the above methods to achieve the desired press fit of the tube 30 in the channel 22. In particular, the execution of the second, third or fourth method can be preceded by the execution of the first method, i.e. by a preliminary temperature induced expansion/shrinking, or the execution of the first, third or fourth method can be followed by the execution of the second method, i.e. by a rolling down of the plate body 10 with the tubes 30 secured in the channels 22.

Fig. 4 shows a finished cooling plate manufactured with the plate body 10 shown in Fig. 1. After having achieved the desired press fit of the tube in the channel 22 of the plate body 10, the tube ends 32, 34 protruding from the bevelled perimeter faces 16, 18 are bent towards the rear of the plate body 10, so as to form a connection pipe-end 60, 62 pointing in a direction substantially perpendicular to a plane parallel to the rear face 14 of the plate body 10. It will be noted that the bevelled perimeter faces 16, 18 form noses 64, 66, which co-operate to protect the bent tube ends 32, 34 towards the interior of the furnace.

Fig. 5 shows a finished cooling plate manufactured on the basis of a plate body 10' having a slightly different design than the plate body 10 of Fig. 1. In this plate body 10', each channel end opens into a recess 70, 72 that is milled into a perimeter face 16', 18' of the plate body 10', so as to be open towards the rear face 14' of the plate body 10'. Towards the front face 12', each of the recesses 70, 72 is closed by a residual plate portion 74, 76. Protected by the residual plate portions 74, 76 towards the front side of the cooling plate, the bent tube ends 32', 34' form connection pipe-ends 60', 62' pointing in a direction

substantially perpendicular to a plane parallel to the rear face 14' of the plate body 10'.

When compared to copper or steel cooling plates having a forged or rolled plate body with drilled conduits for the cooling fluid, respectively to copper cooling plates with a continuously cast plate body in which the conduits for the cooling fluid are cast-in channels, the above cooling plates have e.g. following advantages:

- high quality copper or stainless steel tubes 30, 30' may be used, which warrants leak tightness for many years, even in case of corrosion, erosion, or cracking of the plate body 10, 10';
- as the plate body 10, 10' does not have to warrant water tightness, substantial economies may be made on the quality of the plate body 10, 10', which allows to compensate the expenses for high quality copper or stainless steel tubes 30, 30' by far;
- no necessity to weld connection pipe-ends into the plate body 10, 10', which eliminates an operation that requires highly qualified and experienced man power and always involves a leakage risk due to welding defects;
- the tubes 30, 30' with their bent ends 32, 34, 32', 34' cause a much smaller pressure drop than connection pipe-ends that are welded into a drilled or cast channel;
- the tubes 30, 30' with their bent ends 32, 34, 32', 34' eliminate problems with "dead-ends", such as air pocket and solids accumulations, which are often at the origin of corrosion and flow restriction problems;
- better cooling of the edges of plate body 10, 10', because the tubes 30, 30' emerge out of the perimeter faces 16, 18, 16', 18' of the plate body 10, 10';
- the bent tube ends 32, 34, 32', 34' are able to compensate, at least partially, temperature induced expansion/shrinking of the cooling plate

in the furnace, so that no or simpler compensators will be required for connecting the connection pipe-ends 60, 62, 60', 62' to a cooling circuit.

When compared to cooling plates that are cast within a mould, wherein tubes forming the conduits for the cooling fluid are directly cast-in, the above cooling plates have e.g. following advantages:

- because the plate body 10, 10' may be manufactured on the basis of a rolled, forged or continuously cast slab, it is relatively easy to achieve the plate body 10, 10' free of cavities and porosities;
- slabs for manufacturing the plate body 10, 10' may be industrially produced at low costs and with a constant quality;
- it is not necessary to worry about interface problems between the tube material and a plate material solidifying around the tube;
- the press fit of the tube 30 within the channel 22 allows to warrant good and constant heat transfer properties between the tube 30 and the plate 10, 10'.

CLAIMS

1. A method of manufacturing a cooling plate comprising:

   providing a metallic plate body (10, 10') with a front face (12, 12'), a rear face (14, 14') and at least one channel (22, 22') extending through said metallic plate body (10, 10') beneath said front face (12, 12');

   characterized by:

   inserting, with radial clearance, a metallic tube (30, 30') into said channel (22, 22') so that both tube (30, 30') ends protrude out of said channel (22, 22'); and

   achieving a press fit of said tube (30, 30') within said channel (22, 22') by shrinking the section of said channel (22, 22') and/or expanding the section of said tube (30, 30').

2. The method as claimed in claim 1, wherein the step of providing a metallic plate body (10, 10') with at least one channel (22, 22') comprises:

   a) providing a forged or rolled copper or steel slab; and

   b) drilling said at least one channel (22, 22') through said slab.

3. The method as claimed in claim 1, wherein the step of providing a metallic plate body (10, 10') with at least one channel (22, 22') comprises:

   continuously casting a metallic slab with at least one cast-in channel (22, 22') extending; and

   manufacturing said metallic plate body (10, 10') out of said continuously cast metallic slab.

4. The method as claimed in claim 3, wherein the step of manufacturing said metallic plate body (10, 10') comprises:

   machining said at least one cast-in channel (22, 22') with a metal-cutting tool so as to improve its dimensional and form tolerances.

5. The method as claimed in any one of claims 1 to 4, further comprising:

dimensioning said channel (22, 22') section and said tube (30, 30') section so have radial interference when said plate body (10, 10') and said tube (30, 30') are at the same temperature;

transforming said radial interference in a radial clearance by heating said plate body (10, 10') and/or cooling said tube (30, 30');

when sufficient radial clearance is achieved, inserting said metallic tube (30, 30') in said channel (22, 22') so that both ends protrude out of said channel (22, 22');

wherein said press fit of said tube (30, 30') in said channel (22, 22') is achieved when the temperature difference between said plate body (10, 10') and said metallic tube (30, 30') vanishes.

6. The method as claimed in any one of claims 1 to 5, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises:

rolling down said plate body (10, 10') after insertion of said metallic tube (30, 30') in said channel (22, 22').

7. The method as claimed in claim 6, wherein said plate body (10, 10') is rolled down so as to confer an oval section to said channel (22, 22') and said tube (30, 30').

8. The method as claimed in any one of claims 1 to 7, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises:

radially expanding said tube (30, 30') by establishing a hydraulic pressure inside said tube (30, 30').

9. The method as claimed in any one of claims 1 to 8, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises:

radially expanding said tube (30, 30') with at least one explosion inside.

10. The method as claimed in any one of claims 1 to 8, wherein the step of achieving a press fit of said tube (30, 30') within said channel (22, 22') comprises:

expanding said tube (30, 30') by pulling an expansion head there through.

11. The method as claimed in any one of claims 1 to 10, wherein said plate body (10, 10') is made of copper or steel.

12. The method as claimed in claim 11, wherein said tube (30, 30') is made of copper or stainless steel.

13. The method as claimed in any one of claims 1 to 12, wherein:

each of said tube (30, 30') ends protruding out of said channel (22, 22') is bent towards the rear of the plate body (10, 10'), so as to form a connection pipe-end pointing in a direction substantially perpendicular to a plane parallel to the rear face (14, 14') of the plate body (10, 10').

14. The method as claimed in any one of claims 1 to 13, wherein the step of providing a metallic plate body (10, 10') comprises:

providing a plate body (10, 10') with a first perimeter face (16, 16') and an opposite second perimeter face (18, 18'), wherein said at least one channel (22, 22') extends through said metallic plate body (10, 10') so as to form a first opening (24, 24') in said first perimeter face (16, 16') and a second opening (26, 26') in said second perimeter face (18, 18').

15. The method as claimed in claim 14, wherein at least one of said perimeter faces (16, 18) is bevelled towards the rear face (14) of said plate body (10).

16. The method as claimed in claim 14, wherein for at least one of said openings (24', 26'), a recess (70, 72) is milled into said perimeter face (16', 18'), so that said recess is open towards the rear face (14') of the plate body (10'), and so that said opening (24', 26') lies within said recess (70, 72).

17. A cooling plate comprising a metallic plate body (10, 10') with a front face

(12, 12'), a rear face (14, 14') and at least one metallic tube (30, 30') extending through said metallic plate body (10, 10') beneath said front face (12, 12') so that both tube (30, 30') ends protrude out of said plate body (10, 10'), **characterized by** a press fit between said metallic plate body (10, 10') and said at least one metallic tube (30, 30').

18. The cooling plate as claimed in claim 17, wherein said plate body (10, 10') is made of copper or steel.

19. The cooling plate as claimed in claim 18, wherein said tube (30, 30') is made of copper or stainless steel.

20. The cooling plate as claimed in any one of claims 17 to 19, wherein:

each of said tube (30, 30') ends is bent so as to form a connection pipe-end (60, 62, 60', 62') pointing in a direction substantially perpendicular to a plane parallel to the rear face (14, 14') of the plate body (10, 10').

21. The cooling plate as claimed in any one of claims 17 to 20, wherein:

said plate body (10, 10') has a first perimeter face (16, 16') and a second perimeter face (18, 18'); and

said at least one tube (30, 30') extends through said metallic plate body (10, 10') so that one tube (30, 30') end emerges out of said first perimeter face (16, 16') and the other tube (30, 30') end emerges out of said second perimeter face (18', 18').

22. The cooling plate as claimed in claim 21, wherein at least one of said perimeter faces (16, 18) is bevelled towards the rear face (14) of said plate body (10).

23. The cooling plate as claimed in claim 21, wherein at least one of said perimeter faces (16', 18') includes a recess (70, 72) that is open towards said rear face (14') of said plate body (10') and in which said tube (30') end emerges out of said plate body (10').

Abstract

A method of manufacturing a cooling plate comprises following steps: providing a metallic plate body (10) with a front face (12), a rear face (14) and at least one channel (22) extending through the metallic plate body beneath the front face; inserting with radial clearance a metallic tube (30) into the channel (22) so that both tube ends (32, 34) protrude out of the channel (22); and achieving a press fit of the tube (30) within the channel (22) by shrinking the section of the channel (22) and/or expanding the section of the tube (30).

(Fig. 2)

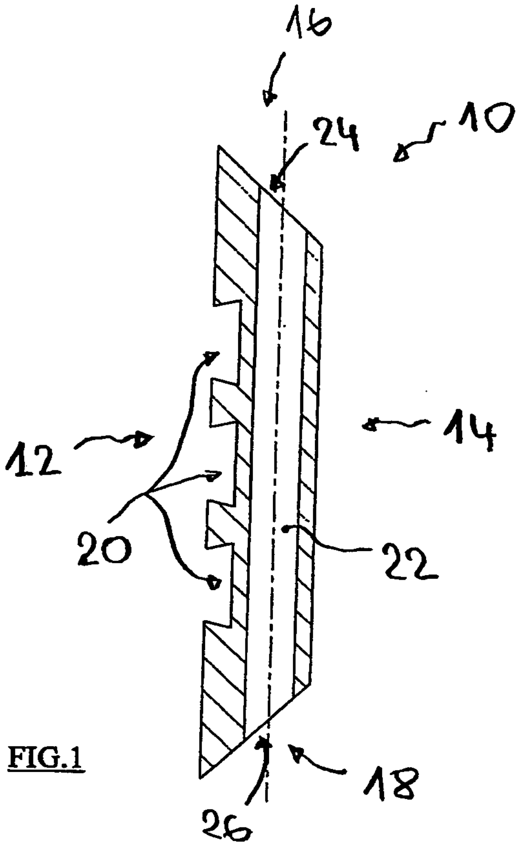

FIG.1

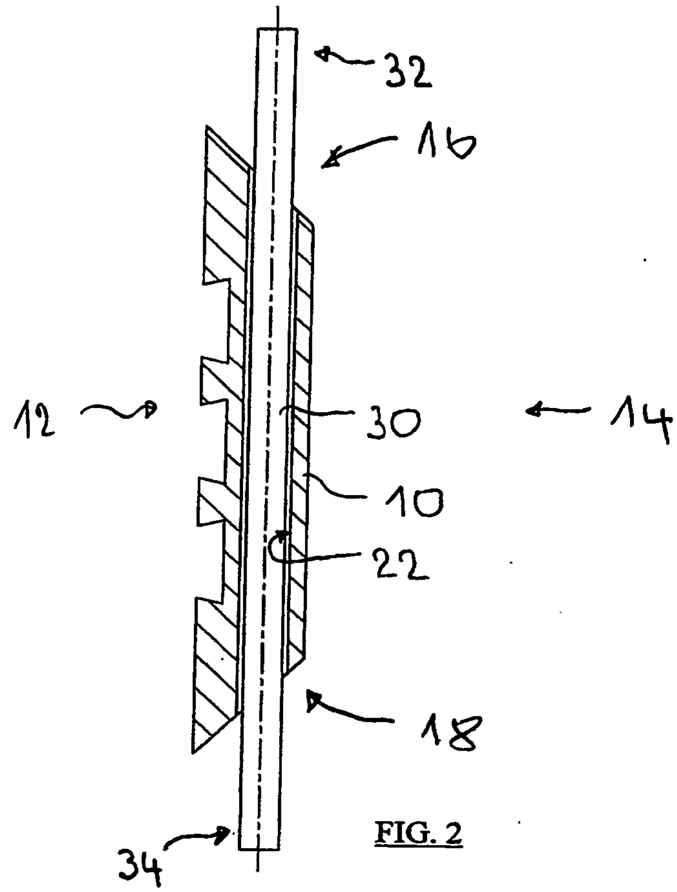

FIG. 2

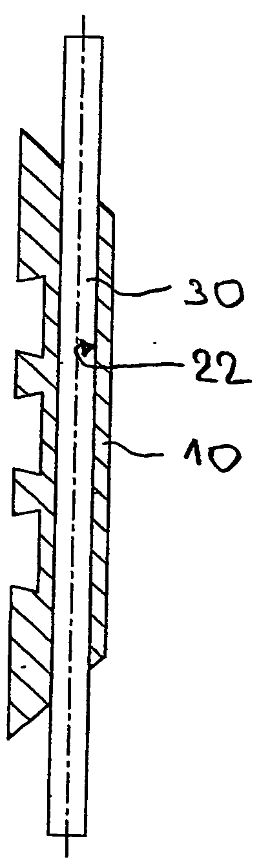

FIG. 3

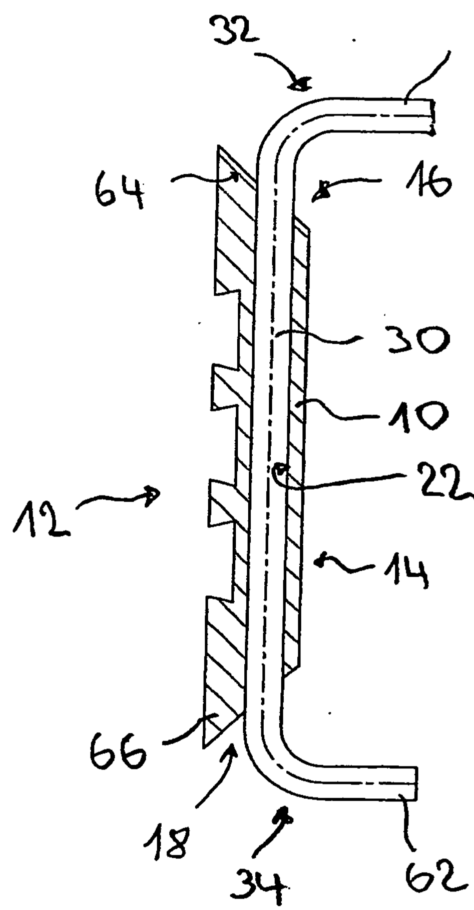

FIG. 4

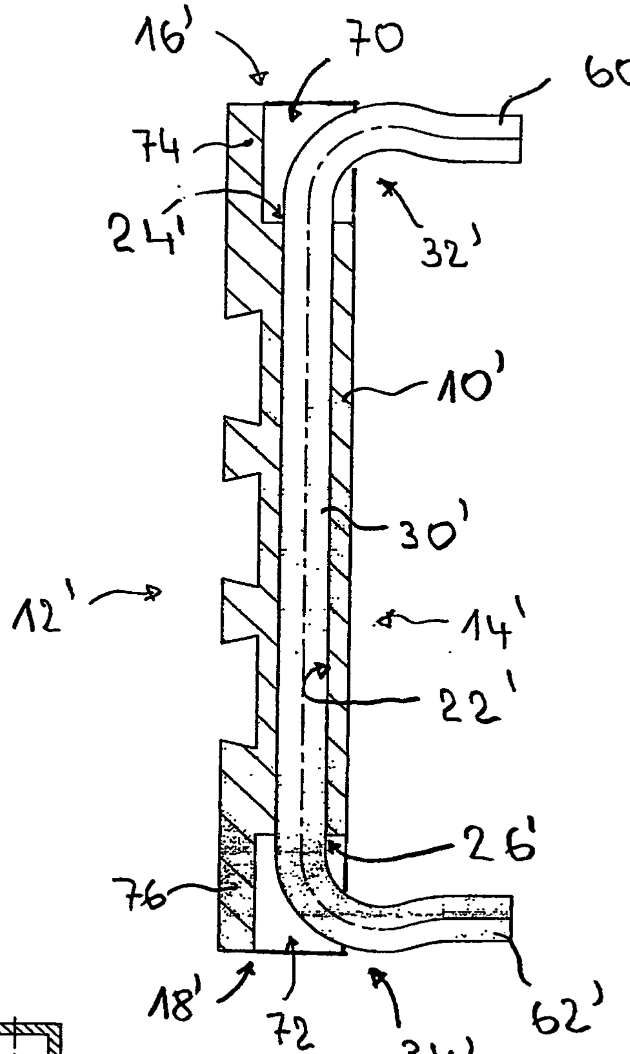

FIG. 5

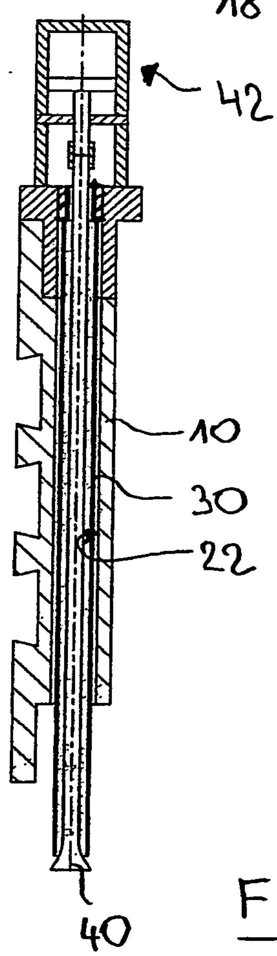

FIG. 6

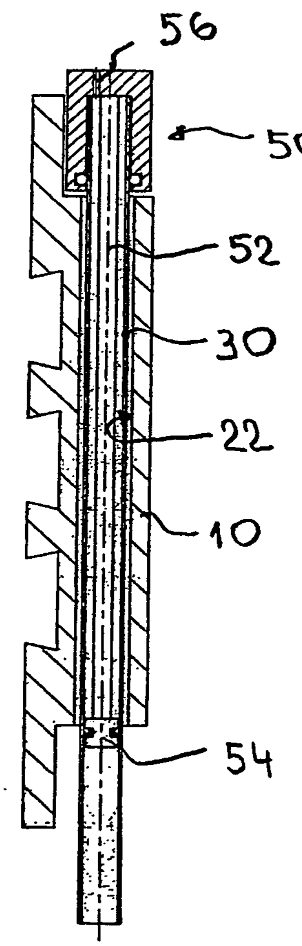

FIG. 7

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